## How To Read A Scientific Paper

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### Reading papers takes practice!

- Scientific papers are full of terms and ideas specific to a field of study – this can seem intimidating!

- Practicing by reading articles is the best way to learn.

- It takes time to become an expert at a field and understand everything that is in a paper.

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### Two main types of papers

- Reviews

- Primary Research Papers

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### Reviews

- General overview of current state of the field

- Often summarize research from many primary papers

- Can be a great resource for:
  – defining terms
  – understanding historical context of your work
  – identifying how the field fits into the bigger picture

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### What to look for in a Review

- Published by an expert in the field
  – Determine if the author(s) have published on the subject before
  – Consider both first and last authors

- Well-recognized journal

- Written in fairly clear language
  – Too technical will lose anyone's attention, and can lead to confusion

- Diagrams are great!
  – Also can be used in your presentations, if properly credited.

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### Primary Research Papers

- Cutting edge research findings - novelty is key

- Data are shown that answer specific questions

- Preferably **hypothesis-driven research**

## General format for a Primary Research Paper

- Abstract
- Introduction
- Materials and Methods
- Results/Data
- Discussion
- References
- Supplementary Material

- **Note:** Not every section may appear independently in every paper

## Five steps to getting the most out of a scientific paper

1. Identify the source of the paper
2. Look for the terms, hypothesis and conclusions
3. Read the sections of the paper
4. Critically evaluate whether the data support the conclusions
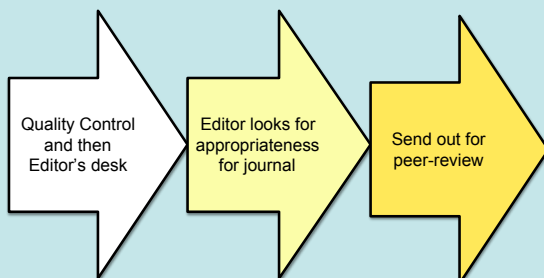5. Apply the data to your own research

## Identify the sources of the paper

- Look at the authors list

- Note the institution that produced the paper
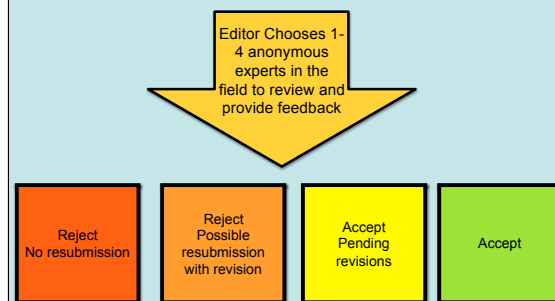
- Is the journal well –respected?

## Authorship Rules

- The International Committee of Medical Journal Editors (ICMJE) defines authors as meeting the following criteria:

  - 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data
  - 2) drafting the article or revising it critically for important intellectual content
  - 3) final approval of the version to be published.

- Standard order is according to contribution, last author usually reserved for the Principle Investigator in the lab

## How does a research paper get published, anyway?

Quality Control and then Editor's desk →

Editor looks for appropriateness for journal →

Send out for peer-review →

## The Peer-Review Process

Editor Chooses 1-4 anonymous experts in the field to review and provide feedback

| Reject No resubmission | Reject Possible resubmission with revision | Accept Pending revisions | Accept |

## What is an Impact Factor?

- **Definition:** a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period.

- IF = Citations / Number of articles published

- Often used to compare the prestige of individual journals. High impact factor = more citations = more prestige

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## Learning terms: start with the Introduction

- Great place to find important terms

- May not be enough background sometimes - look for review papers to fill in the gaps

- Will introduce the model system or organism for the study

- Often will also include the **hypotheses** and/or brief description of the **data**, along with main **conclusion**

## Find the term definitions with the References and Reviews

- The Introduction will introduce you to some terms

- The References section lists works that are summarized or cited in the paper

- Reviews are often the best sources of material for past history of a subject

## How does one locate the hypothesis in a scientific paper?

- If, Then Statements usually do not appear in scientific papers

- In papers hypotheses are tentative statements that propose a **possible explanation** to some phenomenon or event

- Must be testable

- Usually found in the Abstract and Introduction

## Hypothesis Example

- **If, Then Statement:** If skin cancer is related to ultraviolet light exposure, then *high exposure to UV light will cause skin cancer*.

- **As would be seen in a paper:**
  - Our preliminary data suggest that exposure to ultraviolet light will cause skin cancer.
  - We propose that ultraviolet light causes skin cancer
  - Our data will show that skin cancer is caused by ultraviolet light

**Use the Abstract!**

- Often in a very formulaic format:
  - Why this research is important (what does it cure, treat, or explain?)
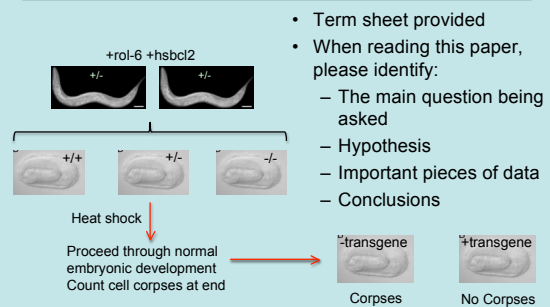  - Hypothesis
  - The most important data
  - The main conclusion

**Find the main conclusions of the paper**

- Often summarized in the **Abstract** or **Introduction** (usually at the end)

- Hint: Most of the conclusions can be found in the **figure legend titles**, or in the **section headings** in the Results section

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**Read the Vaux, et al. paper**



+rol-6 +hsbcl2

+/-     +/-

+/+     +/-     -/-

Heat shock

Proceed through normal embryonic development
Count cell corpses at end

-transgene     +transgene

Corpses     No Corpses

- Term sheet provided
- When reading this paper, please identify:
  - The main question being asked
  - Hypothesis
  - Important pieces of data
  - Conclusions

**Five Steps to Getting the Most Out of a Scientific Paper**

1. How did it feel to read the paper?
2. Identify the source of the paper
3. What was the hypothesis?
4. What are the data?
5. What are the conclusions?

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- Different ways to read a paper

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## Critically Evaluating the Paper

- The ultimate goal for scientists is to publish the data

- Publishing allows other scientists to critically evaluate your work

- You should never accept other scientists' conclusions at face value – **just because they are published doesn't mean they've proven their conclusion with the presented data!**

## Questions for evaluating the data

- Is the hypothesis original and testable?

- Do the authors use a reasonable approach for the problem?

- Is the data reasonable and does it support the authors' conclusions?

- Are there other interpretations of the data?

## How Do You Know If the Data Are Reasonable?

- Examine the Tables/Figures and look for data that meets these criteria:

  – Properly labeled
  – Correct axes
  – Proper controls
  – Reasonable error bars/statistics
  – The data are not manipulated unnecessarily (e.g. with Photoshop, or with excess normalization)
  – Repeat experiments, not repeat replicates

## Example Data

- Properly labeled?
- Correct axes?
- Proper controls?
- Reasonable error bars/statistics?
- Repeat experiments, not repeat replicates?
- What about quantitation?
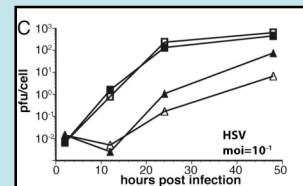


Proc Natl Acad Sci (2008) 105(52):20912-7

## More example Data

- Properly labeled?

- Proper controls?

- The data are not manipulated unnecessarily (e.g. with Photoshop, or with excess normalization)?

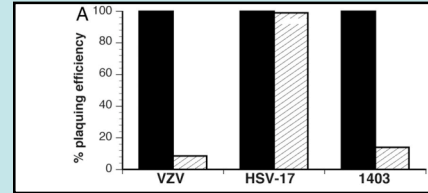- Repeat experiments, not repeat replicates?
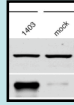
**Are the bands in the top panel different?**

**What about the bottom panel?**

**What if the authors' concluded that the left band, top panel was 20% lower than the right?**

Proc Natl Acad Sci (2008) 105(52):20912-7

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## Example Data



Proc Natl Acad Sci (2008) 105(52):20912-7

- Is it reasonable to conclude that VZV decreases plaquing efficiency?

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## Most Important: Does the data support the conclusions?

- Once the conclusion is identified, pick out the relevant data to support that conclusion

- Sometimes useful to make an outline of the conclusions with the supporting evidence



**Conclusion: Expressing Bcl-2 decreases cell corpses**

**Is this supporting evidence?**
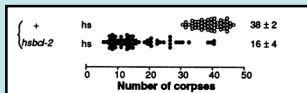
Vaux et al. Science (1992) 258: 1955-7

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## Identify why the findings are important

- What in the research furthers our knowledge?

- Hint: Often found in the discussion

- Example:

  - **Hypothesis:** Programmed cell deaths in nematodes and humans occur by way of the same molecular pathway that is regulated by bcl-2. (Abstract last line, paragraph 2, line 8)
  - **Question asked:** Does the bcl-2 gene regulate programmed cell death in nematodes?
  - **Importance:** Identifying a conserved pathway to regulate cell death

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## Consider how the data could advance the field

- Techniques

- Establishing Controls

- Changing Paradigms

- Create debate, which creates interest

## What can be applied to your own project?

- Look at the Materials and Methods section

- What controls did they use? (parental worms vs. transgenic worms)

- Are there reagents that you could request for your own project? (bcl-2 vector, etc)

## Figure out the next step in the research

- When reading a paper, think about what you would do next

- This may drive future directions for your project by sparking new ideas

- You may also identify potential collaborators

## Think about how to apply this knowledge to another scientific field

- Research is now highly interdisciplinary

- Novel ideas and projects are often discovered by applying a new discovery to other fields or systems

- Challenge yourself to find a way to apply an idea or technology to your own project, especially if it is outside your field

## Final Thoughts

- Learn to use the sections of the paper as a guide

- Most of your effort should be in looking at the data and conclusions

- It is ok to disagree with a paper's conclusions, or think that the conclusions were unreasonable given the data

- Remember: practice makes perfect!